Birthplace, Home and Future of Aerospace

Avionics Acquisition, Production, and Sustainment: Lessons Learned -- The Hard Way

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U.S. AIR FORCE

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

Purpose

- **Address Common Issues/Problems and Highlight Lessons Learned Relevant to Providing Viable Combat Avionics Capability**
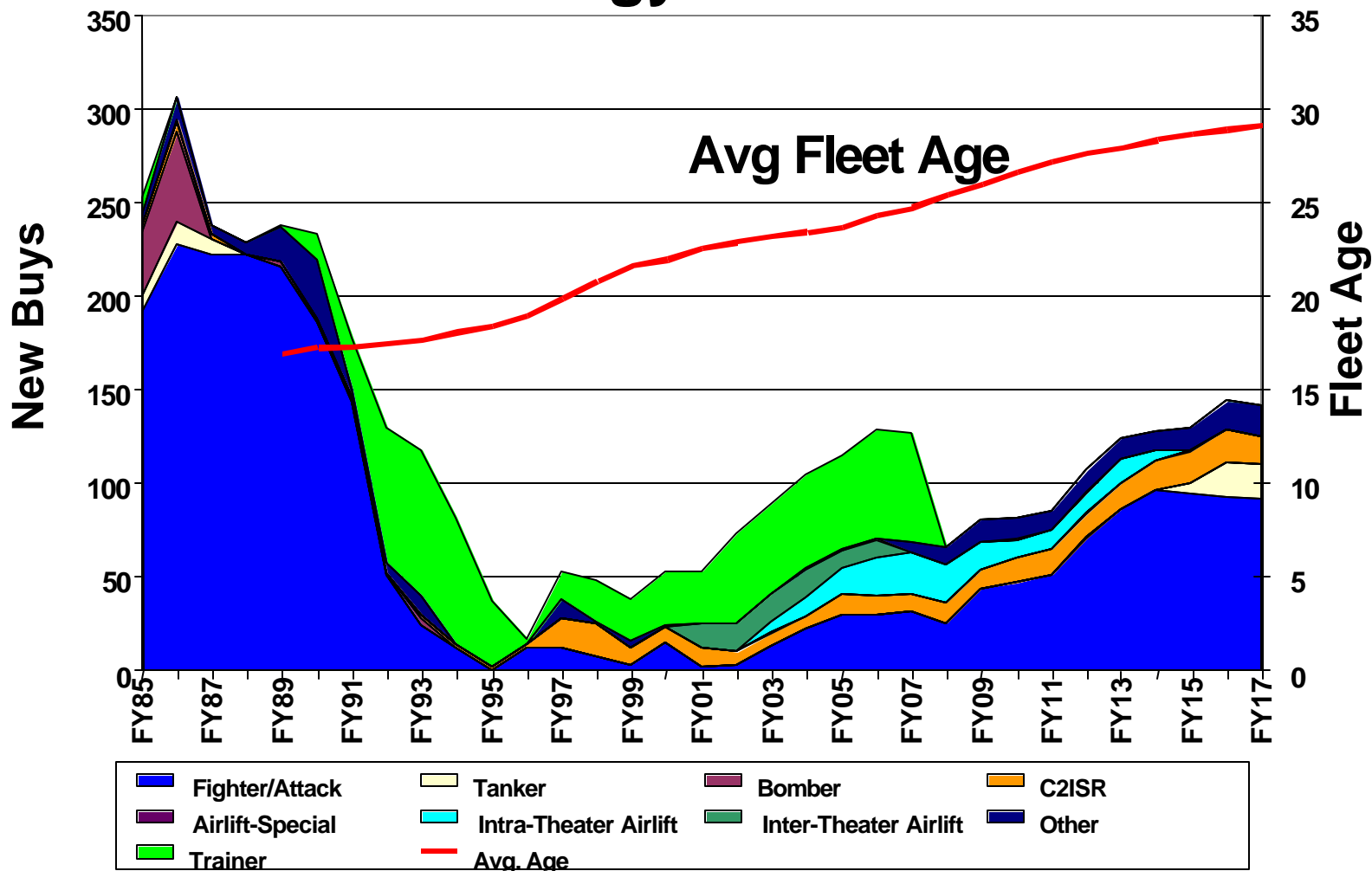
Outline

★ **Background**
- **Today's Environment**
- **Viable Combat Avionics Status**

- **Common Problems**

- **Lessons Learned**

- **Heading**

- **Summary**

Aging Fleet

- ## Continued Technology Insertion is Paramount

Integrity - Service - Excellence

Historical Capability Trend

- ## Sustained - Periodic Growth

Total Onboard Computer Capacity (OFP)

Integrity - Service - Excellence

Historical Capability Trend
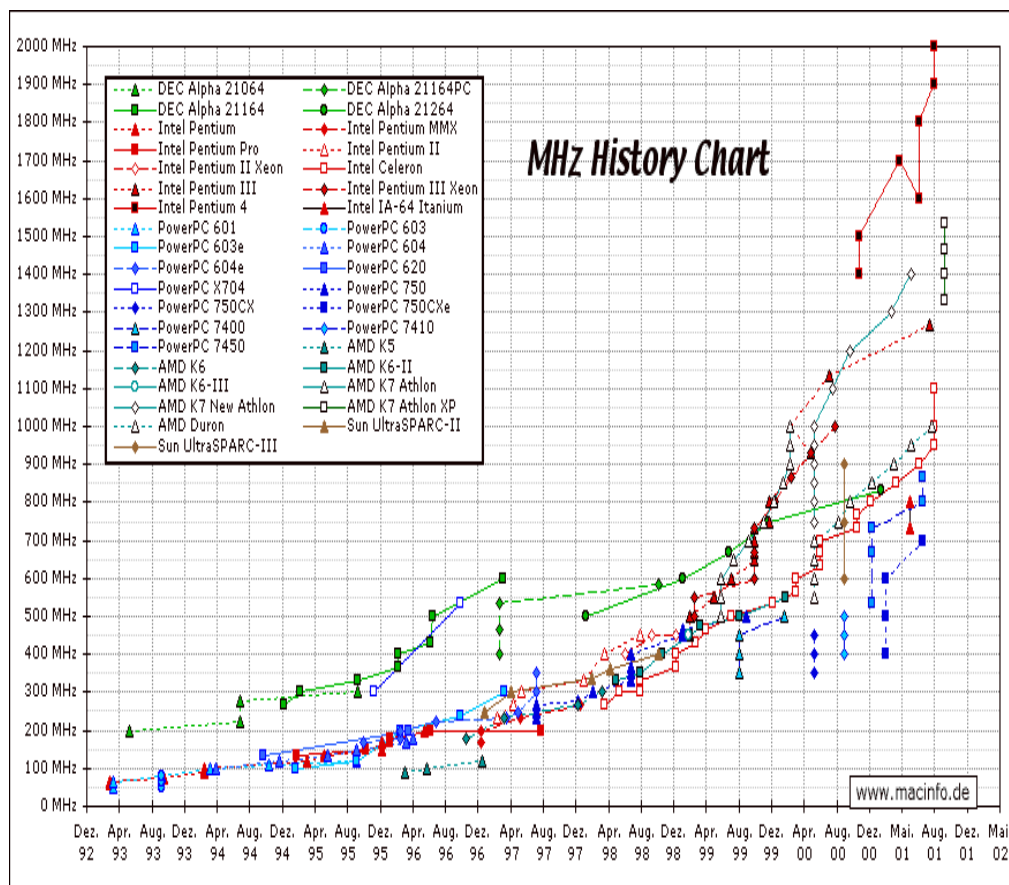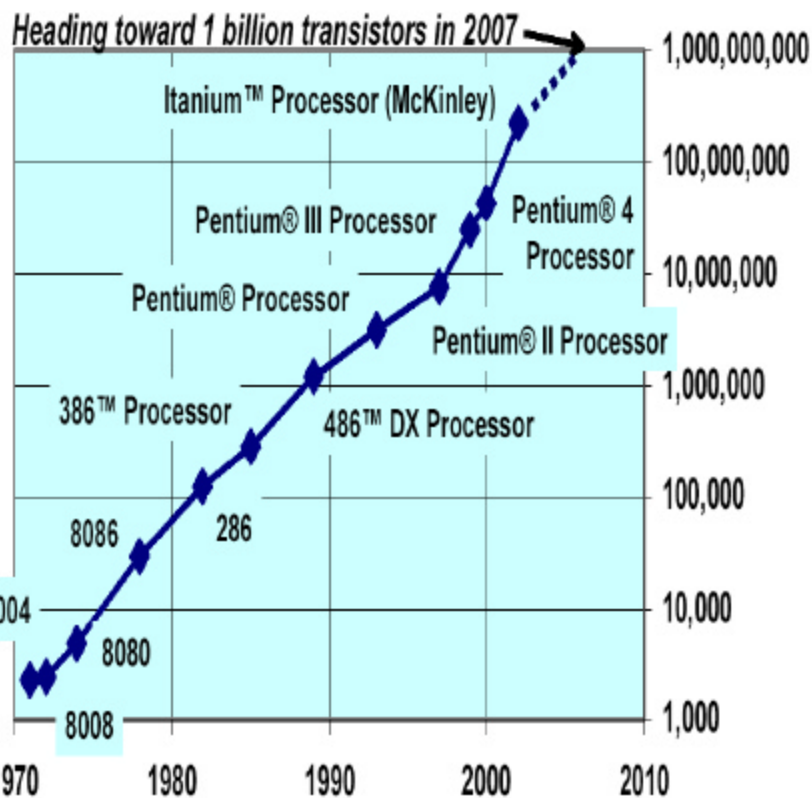
- Sustained - Periodic Growth

Trends In Avionics Aboard Fighter/Attack Aircraft
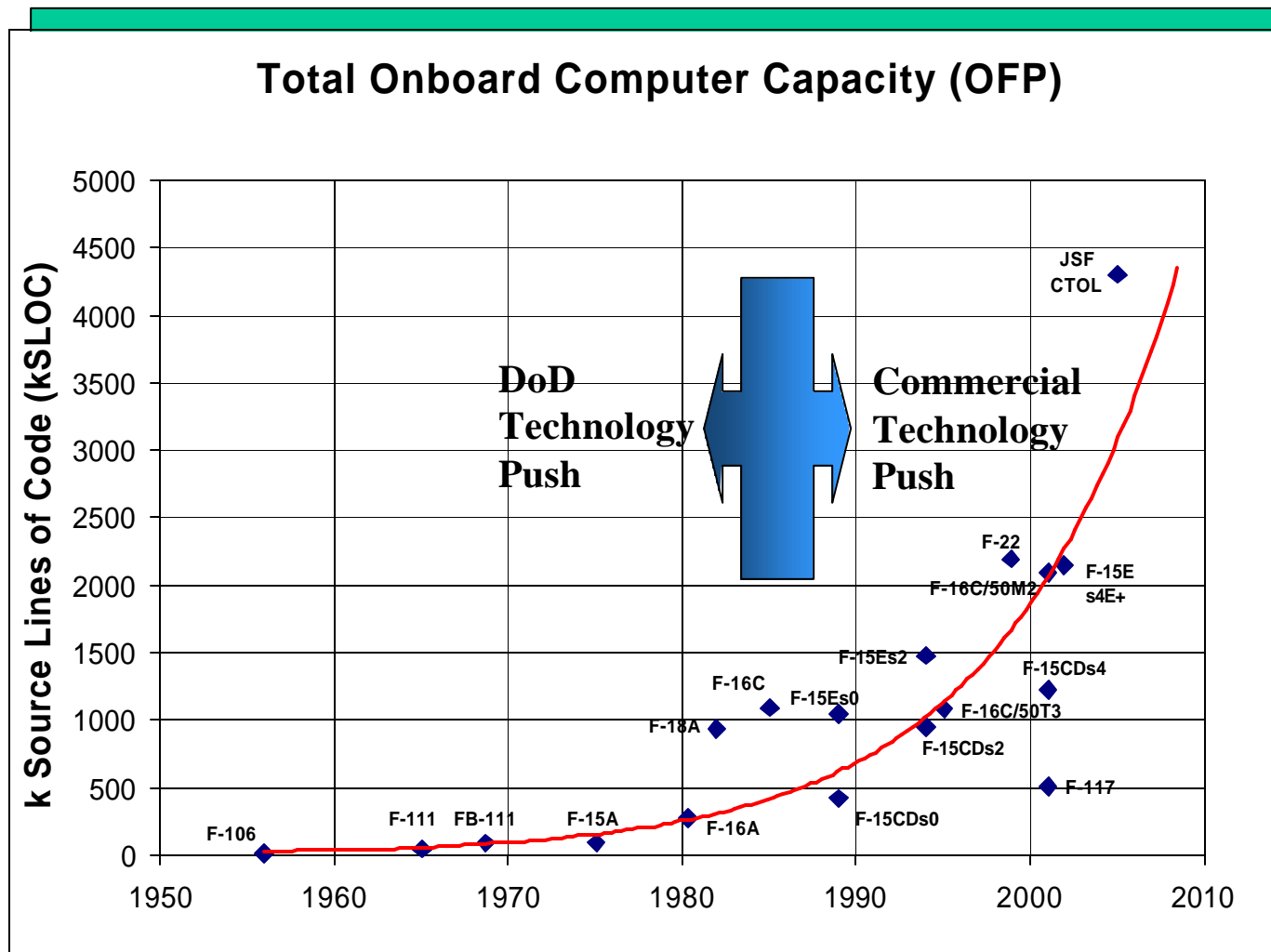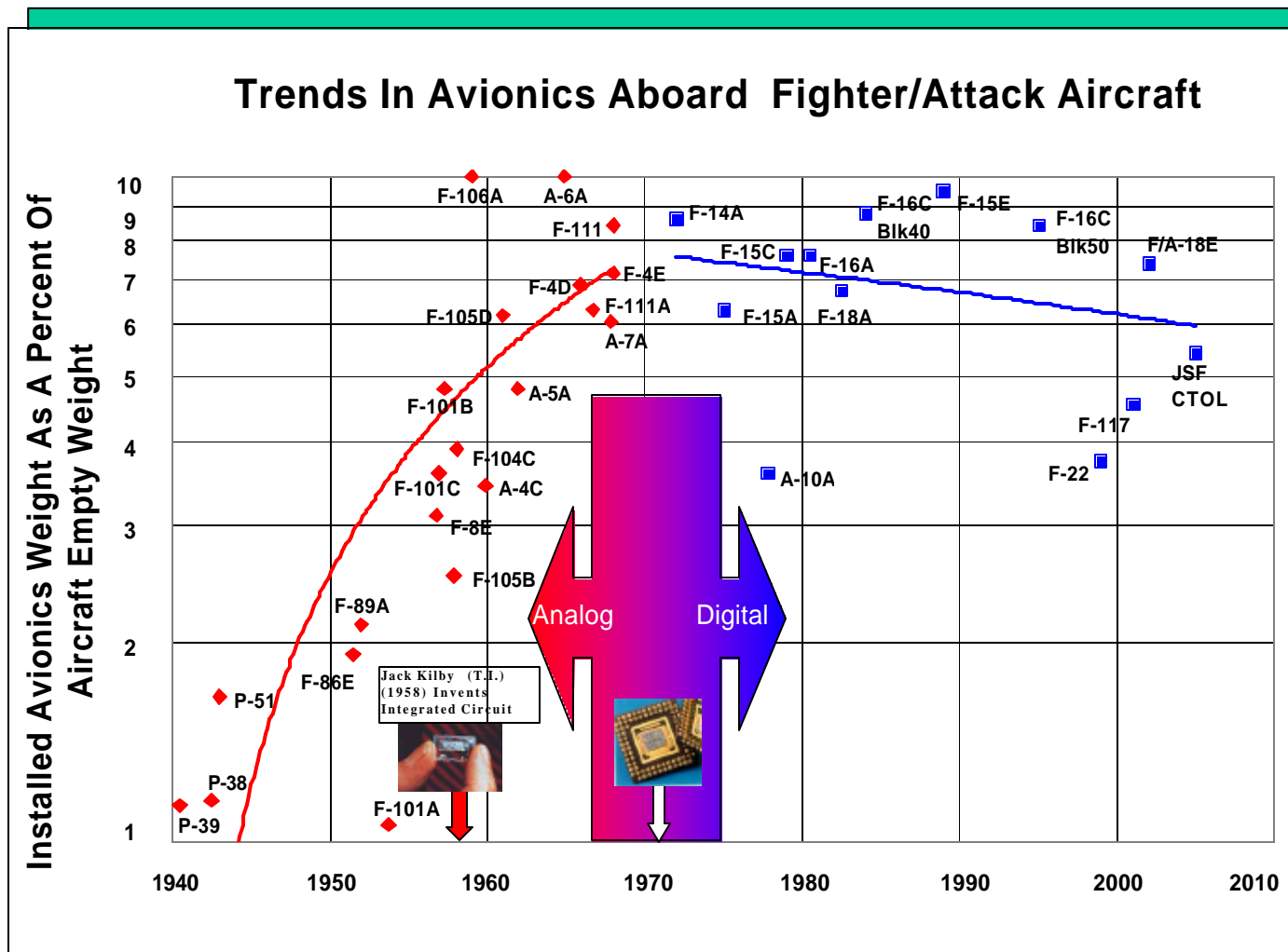
Increased Dependence On Commercial

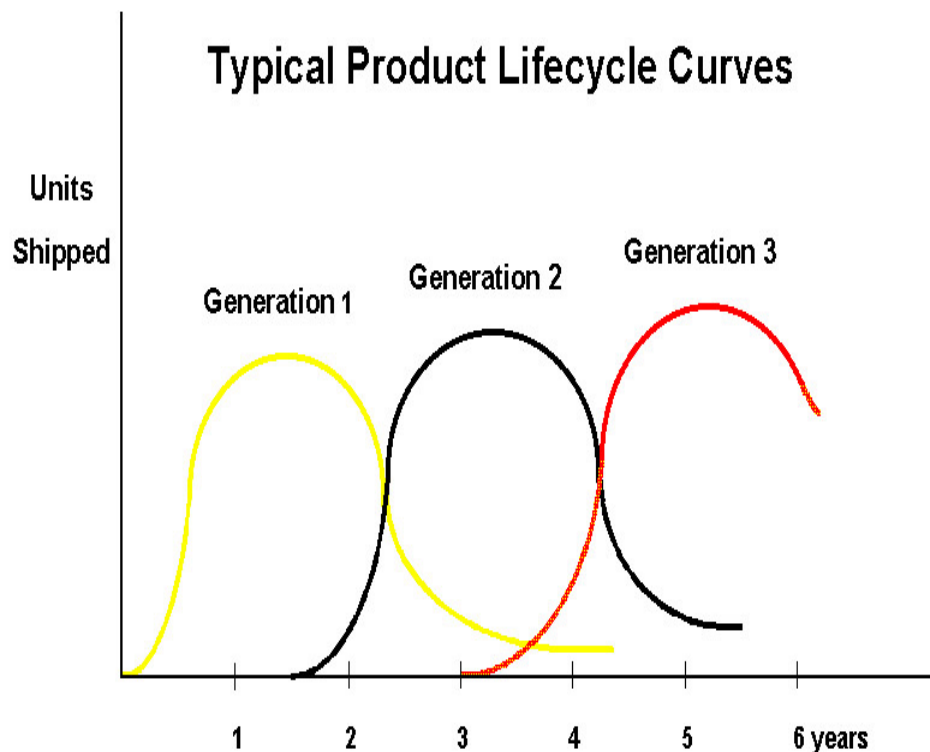- ## Benefit: Performance/Pound/$

Dependence On Commercial (cont)

- ## Liability: Short Term Product Stability/Life Cycle

Typical Product Lifecycle Curves

Units Shipped

Generation 1

Generation 2

Generation 3

1   2   3   4   5   6 years

• The Industry has been on a 2 year cycle for the past decade

• We have not found a fundamental barrier to extending Moore's Law. Scaling <u>will</u> continue!

• Lithography will enable more features per die.

• New materials will enable faster, smaller transistors.

• The greatest challenge will be to drive costs <u>down</u>

Peter J. Silverman, Intel c 2001

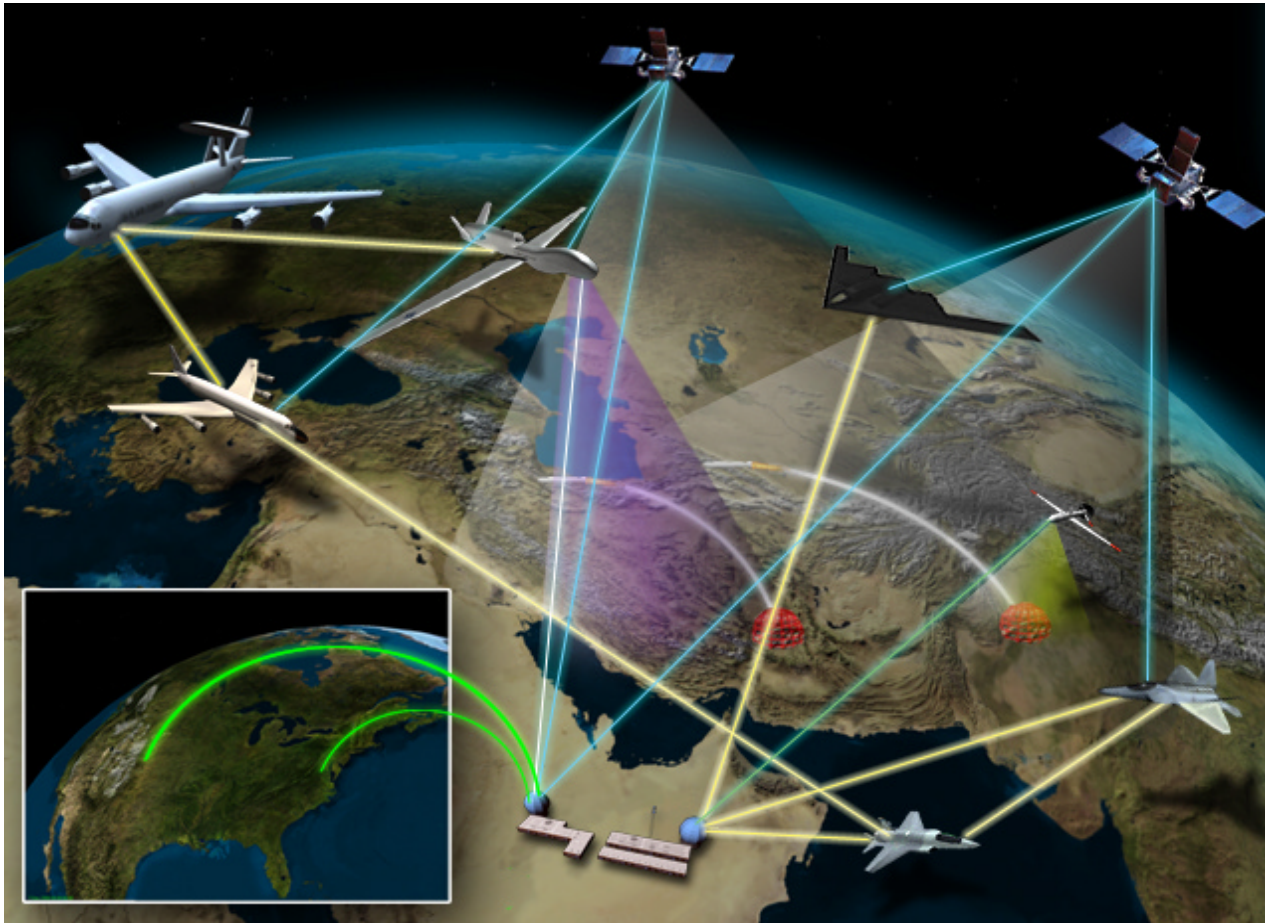Intel Fellow, Technology and Manufacturing

Product Line Life ~ 3-5 years

Transformation

- **Innovative Solutions -- Speed/Capability/Effects Focus**
- **SoS Evolution -- Impacts New/Legacy Systems**

"Present a plan to study the design of avionics systems to preclude their obsolescence:

- For weapons in the field, recommendations on how to *keep those systems current and supportable*

- For future systems, a design strategy that *facilitates substitution of modern electronics over a system's life*"

Action

"Viable Combat Avionics" (VCA) Initiative -- Jul 2000

".... institutionalize the use of:
• affordable open systems architectures
• evolutionary acquisition
• change management roadmaps .... life cycle affordability
• ensure requirements, direction and funding for system upgrades"

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Interim Guidance for Affordable Avionics

On 31 January 2000 we received a briefing, resulting from a Quarterly Acquisition Program Review action item, that detailed a new approach to avionics development, procurement and sustainment. In response, this memo provides broad interim guidance and an integrated strategy for all development and sustainment activities associated with avionics systems under the purview of Air Force Materiel Command to better manage the increasing pace of change in avionics.

This overarching strategy, composed of three key elements, is applicable to new and legacy systems. First, single managers must institutionalize the use of affordable open systems architectures. Second, the requirements, acquisition, and sustainment organization must institutionalize the use of evolutionary acquisition. Finally, we must institutionalize the use of change management roadmaps that integrate operational performance requirements with life cycle affordability requirements. This strategy will be responsive to warfighter needs and provide affordable insertion of current and future technologies. Additionally, opportunities will arise to leverage investment across platforms as weapon systems migrate to broader use of open systems architectures. Implementation will require the operating Major Commands to coordinate closely with Materiel Command, and ensure requirements, direction and funding for system upgrades capture the elements of the overarching strategy.

Lt Gen Robert Raggio, Aeronautical Systems Center (ASC) Commander, is leading this initiative. He has established a Chief Avionics Architect for Aircraft Systems within ASC/EN to assess and validate architectures and change management roadmaps. Additionally, the ASC Commander has created an IPT composed of acquisition, logistics, and operational representatives from government and industry to develop a framework of policies, tools and processes to facilitate this effort. Single managers will use these tools and processes to implement the integrated, affordable avionics strategy. Shortly, single managers will receive further program direction to initiate trade studies and develop migration plans. We need your full cooperation and support to successfully execute this new avionics strategy.

Michael E. Ryan
General, USAF
Chief of Staff

F. Whitten Peters
Secretary of the Air Force

DISTRIBUTION:
See Attached List

Viable Combat Avionics Status

- **Recognition and Effort Have Increased**
  - **Aeronautical Enterprise Focus**
    - Acquisition Strategy Review Emphasis
      - Approach to Open, Affordable Architecture
    - Architecture Source Selection Criteria
  - **Time Phased Architecture Roadmaps**
    - Link Requirements/Plans/Funding
  - **Avionics Best Value Methodology**
  - **Fund High Payoff Technologies**
    - Electronics, Structures, Subsystems

However

…. We are Still Experiencing Major Problems

- **Cost Overruns**
- **Program Cancellations**
- **Extensive Test and Verification**

- **Some Due to Outside Contributor, e.g. Changed Requirement and/or Budget**
- **Too Often** **Technical Accomplishment**

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Problems - Consequences
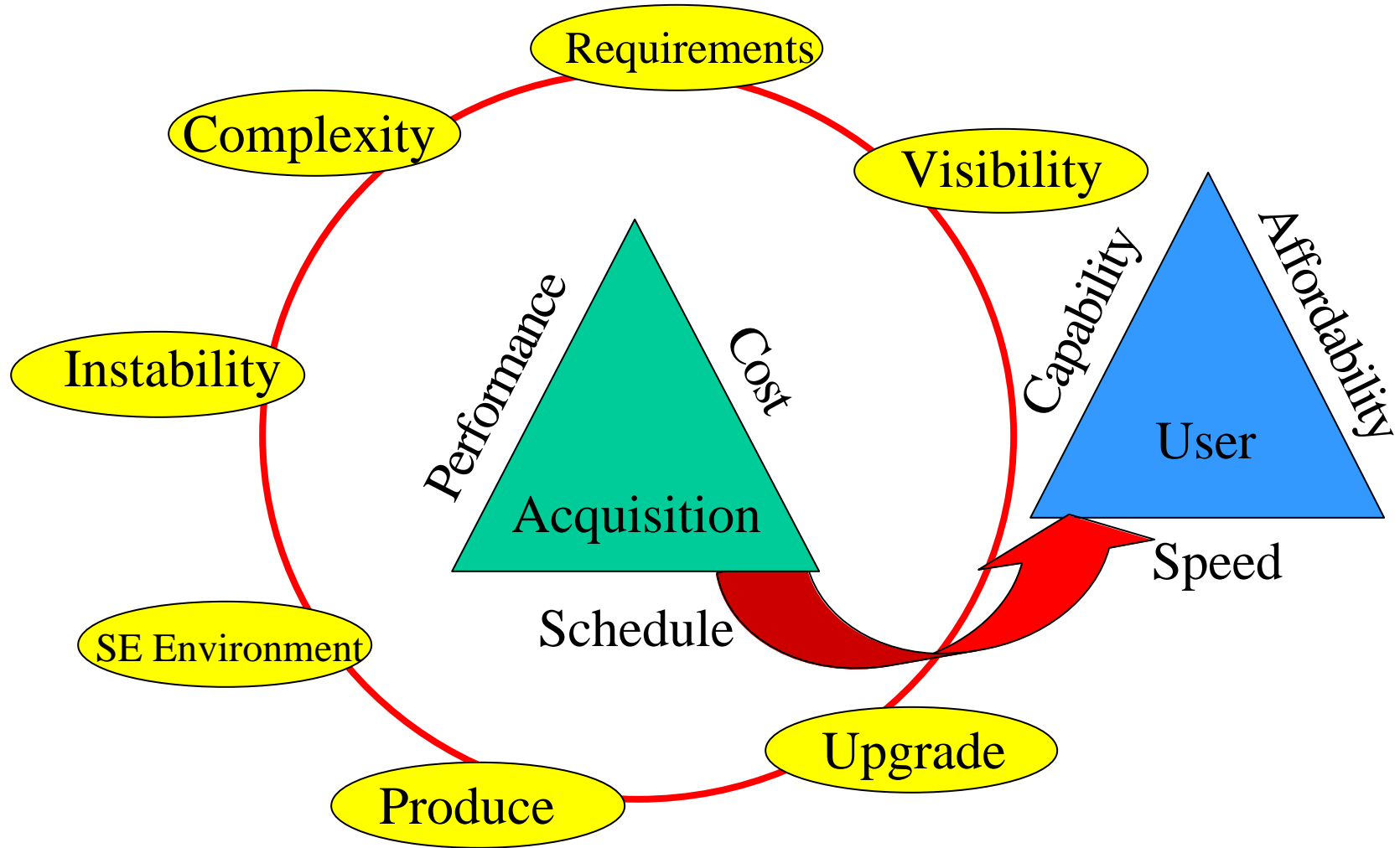
Common Problems

- **Longer Than Expected Time to Integrate and Test**
  - **Weak Requirements Allocation**
  - **Product Maturity Visibility**
  - **Complex Implementations**
  - **Instability**
  - **Limitations in Systems Engineering Support Environment**
- **Can't Produce What is Being Qualified**
- **Difficult to Upgrade -- Sustainment Phase**

Requirements Allocation

- **Poorly Defined Functional Requirements and Verification Criteria**
  - **Lack Traceability to Higher Functions**
  - **Key Characteristics Not Understood**
    - Tolerance to Off Nominal Conditions
    - What to Test/How to Test-Stress Design
  - **Poor Estimate of Resource Requirements**
  - **Immature Products Accepted to Next Level**
    - Hidden Complexity -- Difficult to Identify
  - **Products Fail Higher Level Integration/Test**
    - Amplifies Cost/Schedule Impact

Product Maturity

- **Poor Insight Into Product Maturity**
  - **EVMS Results Don't Predict Status**
    - Inadequate Technical Measures
    - False Indications of Maturity
  - **Returned Work/Correct Deficiencies**
    - Resource Impact (e.g., Reconstitute or Red Team)
    - Cost Impact
    - Schedule Consequence -- Critical Path?
  - **Hold Schedule -- Accept Risk**
    - Deficiencies Passed Forward
    - Time/$ Expense to Fix

Complexity

- **Functions Involve Many Owners**
  - **Problems Impact Multiple Levels of the Architecture**
    - Difficult to Trace and Understand
  - **Problems Impact Multiple Organizations**
    - Within Prime Integrator and/or Sub-Suppliers
  - **No Change is Simple -- Increased Overhead**
- **Edge of Technology Solutions**
  - **High Performance/High Criticality/High Risk**
    - Tight Margins/No Tolerance to Off Nominal
    - Difficult to Understand/Define Measures
    - Can't Simulate/Added Hardware-Software Risk

Instability

- **Excessive Anomalous States/Conditions**
  - **More Resource Capacity Required Than Planned**
  - **Insufficient Timelines and Margins**
    - Sensitivity to Small Variability
  - **Complicated Problem Resolution**
    - Hardware Only -- Software Only -- Hardware/Software
    - Significant Growth in Verification and Test
      - Minimize Unknown States
      - Achieve Repeatable Behavior

- **Unexpected Tech Insertion -- DMS**

SE Environment

- **Adequate Systems Integration Facilities**
  - **Late to Need**
  - **Insufficient Level of Robustness/Fidelity**
    - Lack Real Hardware/Interconnects/etc
    - Inability to Resolve Problems
  - **Conflicting Designer/Tester Needs**
    - Usage Competition
    - Non-Dedicated Hardware
  - **Reduced Confidence in Product Maturity**
    - Problems Passed to Flight Test -- $/Time Impact

Production

- **Excessive Change to Bill of Materials**[*]
  - **Product Baseline Impacted**
    - Consequence of Concurrency
    - Excessive Supplier Product Turnover
    - Life of Type Strategy Doesn't Work
    - Planned Migration Effort Larger Than Expected
  - **Increased Systems Engineering Costs**
    - Redesign, Regression Test, Documentation, etc
  - **Outside Budget Cycle**
    - May Add Further Delays/Increase Scope of Change

[*] May Occur During Any Phase of the Program

Sustainment

- **Pace of Technology Change**
  - **Stresses Resources**
  - **Difficult to Plan and Predict Impact**
  - **Technical Data Lacks Original Verification, Critical Characteristics, etc**
    - Difficult to Re-Engineer
    - Uncertain Level of Test and Verification
  - **Modernization - Sustainment Misalignment**
    - Simultaneous Improvement
      - New Requirements vs Parts/Mission Capability
      - Short Lived Configurations
      - Cost Inefficiency

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Lessons Learned

- ## **Original Architecture Tends to Have Long Life**
    - ### **Establishes the Aircraft "Motherboard"**
        - Interconnect, Weight, Volume, etc
    - ### **Sets Future Capability Growth Constraints**
    - ### **Expensive to Change**
        - Depot Level of Effort Required
    - ### **New Thinking Warranted?**
        - Data, Power, Cooling Services

Lessons (cont)

- **Technology Cycle Has to be Managed**
  - **Modular and Function Based Architectures are Essential**
    - Change/Tech Insertion is the Norm
    - Favorable Technology Performance/Cost Forecast
    - Short Product Life Cycles Must be Factored
  - **Forces a Focus on Evolutionary Acquisition**
    - Block/Spiral Capability Emphasis
    - Incremental User Requirements/Funding Essential
    - Product Life Management is Now a Performance Requirement
      - Contractual Proof -- Affordable Technology Insertion

- **Thorough, Complete Product Technical Definition is Essential**
  - **60-70% of Program's Cost Occurs After CDR**
  - **Integrated Key Characteristics and Verification Measures Must be Defined, Proven and Managed**
    - Reflects Stable/Repeatable Design Behavior
    - Enables "Open" Objectives to be Achieved
    - Minimizes Downstream Technology Insertion Cost
      - Amount of Regression (Post CDR Effort)
  - **Critical For Production/Sustainment Strategy**

Lessons (cont)

- **Recognize Risk in Pursuing Complex Architecture Solutions**
  - **Edge of Technology Comes at a High Price**
    - Generally Slow to Provide Capability to User
      - Difficult to Achieve Hardware/Software Stability
      - Hardware/Software Often Tightly Coupled
      - Extended Testing/Slow Transition to Production
    - Costly to Change
      - Complex Functions Impact Multiple Levels
      - Limited Supplier Base
      - Future Technology Insertion Is Radical not Evolutionary

Lessons (cont)

- **Strong, Stable Systems Engineering Environment is Essential**
  - **Manage Same as Prime Mission Equipment**
    - $ Investment for Life Management Required
  - **Early Recognition and Planning Critical**
    - Simulations, Facilities, and Tools
    - Replicate A/C Installation
      - Flight Hardware, Cables, etc
  - **Multi-Dimension Usage**
    - Design/Integration
    - Formal Verification/Test
    - Problem Resolution

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Heading

- **VCA Requirements, Tools, and Strategy Progressing, but Not Fully Developed/Deployed**
- **Actions**
  - **Continue Emphasis On Incremental User Requirements and Funding**
    - Link to Program Roadmaps
  - **Refine Source Selection Criteria**
  - **Develop Contractual Specification Language**
    - Functional Performance and Verification
  - **Develop/Incorporate Senior Level Review Criteria**
  - **Pursue High Return Technologies/Capabilities**
    - Emphasis on Cost Avoidance/Speed

Promising Tools

- **Extended Bandwidth Mil Std 1553**
  - **Non-Interference Capability on 1553 Network**
    - Ease of Expansion
    - No Depot Rewiring
  - **FY03 Demonstrations**
    - Joint Government/Industry
      - Ogden ALC F-16 Block 30 Demo
      - Prime Contractor SIL
    - 300 Mbit/sec and Higher -- Real Time Suitable
    - Open Standard Product by 04/05
    - AF POC: William Wilson, ASC/ENA, 937-255-9274

Objective

- **Viable Combat Avionics**

Avionics Whose Design <u>and</u> Systems Engineering Provide a Capable, Timely, and Affordable Product Throughout All Life Cycle Phases

Summary

- **Changing Environment/New Challenges**
  - **Extended Service Life**
  - **Rapid Technology Change**
  - **New Requirements/Transformation**
- **Progress, But Problems**
  - **Drive Cost**
  - **Delay Capability to User**
- **Lessons Learned Help Define Way Ahead**
- **Actions/Processes/Tools Focused Under VCA**
  - **Aeronautical Enterprise Leadership**